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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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NSF 15-585	11/03/15	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) DUE - IUSE- Exploration & Design: Engaged Student Learni		[redacted]

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856000545	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Northern New Mexico College	Northern New Mexico College 921 Paseo de Onate Espanola, NM. 875322649
AWARDEE ORGANIZATION CODE (IF KNOWN) 0002378000	
NAME OF PRIMARY PLACE OF PERF Northern New Mexico College	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE Northern New Mexico College 921 Paseo de Onate Espanola ,NM ,875072649 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **EDUCERE: Ensuring Diversity and Undergraduate Completion: Enrichment and Retention In Engineering**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 299,998	36 months	08/01/16	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
- ☒ FUNDING MECHANISM Research - other than RAPID or EAGER
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
- ☒ COLLABORATIVE STATUS Not a collaborative proposal

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Engineering	921 Paseo de Onate Espanola, NM 875322649 United States
PI/PD FAX NUMBER	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification (If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

CERTIFICATION PAGE - CONTINUED

Certification Regarding Organizational Support

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Federal Tax Obligations

When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations. By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME [redacted]		Electronic Signature	Nov 4 2015 8:54AM
TELEPHONE NUMBER [redacted]	EMAIL ADDRESS [redacted]		FAX NUMBER [redacted]

NATIONAL SCIENCE FOUNDATION
Division of Undergraduate Education

NSF FORM 1295: PROJECT DATA FORM

The instructions and codes to be used in completing this form are provided in Appendix II.

1. **Program-track** to which the Proposal is submitted: **IUSE- Exploration & Design: Engaged Student Learni**
2. Name of **Principal Investigator/Project Director** (as shown on the Cover Sheet):
   [redacted]
3. Name of submitting **Institution** (as shown on Cover Sheet):
   Northern New Mexico College
4. **Other Institutions** involved in the project's operation:

Project Data:

A. Major Discipline Code: **58**
B. Academic Focus Level of Project: **BO**
C. Highest Degree Code: **B**
D. Category Code: --
E. Business/Industry Participation Code: **NA**
F. Audience Code: **WMD**
G. Institution Code: **PUBL**
H. Strategic Area Code: ____
I. Project Features: **1 2 3 4 6**

Estimated number in each of the following categories to be directly affected by the activities of the project during its operation:

J. Undergraduate Students: **70**
K. Pre-college Students: **800**
L. College Faculty: **3**
M. Pre-college Teachers: **0**
N. Graduate Students: **0**

PROJECT SUMMARY

Overview:

Northern New Mexico College (Northern) serves a 77% underrepresented minority (URM) and extremely underprepared population that requires one or more years of remediation. This leads to high rates of attrition in the first two years, especially in STEM programs. The College of Engineering and Technology is deeply interested in developing a research-generated knowledge base of how its student demographic learns complex foundational Physical Science concepts. This project seeks to determine: 1) if early introduction to Physics concepts through active learning and project based activities before taking a theory-based course will lead to increases in learning, understanding, application of foundational concepts, and greater success in upper division courses; and 2) whether Native American and Hispanic students with high degrees of interdependent self-construal respond better to active learning prior to theoretical learning. Also, undergraduate research experiences (URM), widely known to foster enhanced preparation and commitment to pursuing graduate studies in STEM and greater clarity on future career pathways, will be provided to upper division students to prepare them for the STEM workforce. Objectives include increasing: enrollment by 45%, first to second year retention by 27%, and first to third year by 79% over three years; URE and workforce opportunities for upper division students. Matched subjects samples methodology and a modification of the Solomon four-group research design will test whether active learning in a new introductory course, Applied Sciences for Engineering Freshmen, prior to taking a theoretical learning course, improves learning of foundational Physics concepts and contributes to retention in the first two years.

Intellectual Merit :

This project is important for the advancement of scientific knowledge and understanding of those practices that most effectively retain and train students in engineering. Students come from unique, rural, ethnic, isolated, tightly knit communities, which may affect persistence. Their perceptions of STEM may be heavily impacted by their self-construal as interdependent rather than individualistic. Educational programs that take this into account are key to retention and persistence, and any assessment of effectiveness should include these measures for URM populations. Understanding how underrepresented and highly underprepared students learn complex, Math-intensive Physical Science concepts has the potential to: 1) advance knowledge of how unique URM populations learn Physical Science concepts; 2) contribute to the body of education research of elements most effective in engineering teaching and URM learning; 3) add to the evidence base of successful strategies that broaden URM participation in engineering programs; 4) create a pipeline for URM engineer graduates entering STEM graduate programs and careers; and 5) increase the contributions that Native Americans, Hispanics and women will make to new understandings and innovations in science and technology.

Broader Impacts :

This project addresses the concerns of: 1) low URM in engineering undergraduate and graduate programs and the STEM workforce; 2) the loss of intellectual and cultural assets of this region, and others with similar unique cultural populations that are rural, not highly educated, interdependent, from similar socioeconomic backgrounds, and emanating from families/communities in which the social fabric is strained; and 3) diversification of engineering for greater innovation and emerging breakthroughs. Positive results of introducing more Math- and Physics-deficient URM in their first year to real-life examples of engineering projects and creative project-based approaches to learning basic Physics will lead to greater confidence in student?s academic abilities and thereby increase the number of URM persisting in and graduating with engineering degrees. Finally, by incorporating classroom strategies that lead to success, and supporting upper division undergraduate students in engineering research, more URM will be able to contribute to the diversity and ingenuity required to solve regional, national and global problems, and preserve the health and economic well-being of this and other nations.

TABLE OF CONTENTS

For font size and page formatting specifications, see PAPPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

INTRODUCTION TO NORTHERN NEW MEXICO COLLEGE

Northern New Mexico College (Northern) meets the designation requirements as both a Hispanic- and Native American-serving institution. Since 1909, the institution has transitioned from a normal school to a vocational technical school, then to a community college, and in 2005 to a comprehensive four-year degree-granting institution. Over the past decade, Northern has developed a STEM program that includes Biology, Chemistry, Environmental Science, Mathematics and Physical Sciences, and Engineering. The College of Engineering and Technology's (CET) degree programs in Information Engineering Technology and Electromechanical Engineering Technology (EMET) are the driving force behind Northern's STEM growth. However, despite high enrollment in these programs, retention in the first two years is very low (55% from year 1 to year 2; and 28% from year 1 to year 3).

Northern's service area is home to a unique ethnic distribution that includes eight Northern Pueblo Tribes and the Jicarilla Apache Tribe, which together comprise 18% of the population of Rio Arriba County (compared to 1.2% nationally); and centuries old Hispanic communities, which constitute 71% of the population (versus 16.7% nationally; US Census, 2014). The northern New Mexican Hispanics are as culturally unique as the local Native American populations. They are unlike any other community designated "Hispanic" in the US, as they enjoy a 400-year insulated history in America after migrating from Spain, and have retained very specific linguistic and cultural characteristics more concretely identified as Spanish rather than Mexican or Latin American. The region struggles with endemic poverty, a dearth of employment opportunities, rural marginality, and a marked underrepresentation in baccalaureate degree attainment (16.4% in Rio Arriba county compared to the national average of 28.8%; US Census, 2014). However, these distinct populations have amassed significant cultural, artistic and creative assets that if properly developed and inspired, could increase STEM completion rates among underrepresented populations, diversify the nation's STEM workforce, and provide creative solutions to complex regional, national and global problems.

Like most academic institutions in the US, Northern struggles to retain its first generation (58%), underrepresented minority (URM; 77%), and academically underprepared students (83% compared to the national average of 60%). This large gap in college readiness is due to poorly performing public schools (87% of K-12 regional schools failed to meet the 2011 NCLB AYP). The low average retention for all Northern students in the first two years (40% year 1; 50% year 2, respectively), and low graduation rates (17%, compared to the 2014 national average of 55%) for first-time, full-time students seeking a Bachelor's degree and completing within six years (National Center for Education Statistics, 2015), all provide opportunities for Northern and its STEM programs to begin developing a research generated knowledge base for understanding how its students learn.

STATEMENT OF WORK

This Engaged Student Learning: Exploration and Design grant proposal, entitled, *Ensuring Diversity and Undergraduate Completion: Enrichment and Retention In Engineering* (EDUCERE), seeks funding to build evidence regarding how best Northern's unique underrepresented and academically underprepared students learn complex Physical Science concepts. Electromechanical Engineering Technology (EMET) faculty will re-envision the teaching and curricula, as well as the sequence of Physics course offerings for EMET majors. A new, first-year, introductory Physics course, *Applied Sciences for Engineering Freshmen* (ENGR 116), will be designed and implemented within the EMET degree program that will employ project-based, hands-on, engineering-contextualized, active learning projects with specialized engineering equipment (e.g. wind tunnel and electric vehicle trainer). This course will be taken by Freshman EMET majors *prior* to taking the traditional sophomore-level Physics course, Engineering Physics 1, a 3 credit theory course with a credit 1 Lab, in which students are first presented with theoretical learning. It is critically important to determine if early exposure to Physics concepts through hands-on and applied methodologies fosters greater ability to learn and apply Physics, as the majority of students taking Engineering Physics 1 do not have the proper background in the Physical Sciences to succeed. This not only affects their success in the sophomore-level Physics course,

but their performance in later engineering courses, as well. It also likely contributes to the high rate of attrition from year one to year three among engineer majors (72% attrition).

The social science research will utilize the Matched Subjects Design, a special case that assures group equivalence at the start of a study when random assignment is not possible, as further delineated in the Experimental Methods section. Matched pairs of students in the treatment group (students who take ENGR 116) and the control group (students who do not take ENGR 116) will be examined for: 1) learning outcomes and mastery of content knowledge in the Engineering Physics I course to determine whether greater learning competency occurs when Physics is first introduced with active learning *prior* to theoretical learning; and 2) whether Native American or Hispanic students with high degrees of interdependent self-construal respond better to applied learning *prior* to theoretical learning, as compared to matched pairs with low degrees of interdependent self-construal.

In addition to the research on activities developed for Freshman students in their first two years, EDUCERE also seeks to implement the best practice of incorporating faculty-mentored undergraduate research experiences (URE) for a small number of upper division EMET students. By providing paid research internships to students who would otherwise be working off campus in non-academic jobs to pay for their college expenses, they can be gaining important research experience and analytical and problem-solving skills necessary to become leaders and innovators in STEM careers. Undergraduate research experiences are known to enhance student confidence, preparation and commitment to pursuing graduate studies or entering the engineering workforce.

GOALS, OBJECTIVES, AND EXPECTED SIGNIFICANCE

Goals and Objectives: The goals of this project are to: improve the knowledge base regarding those practices that lead to effective engineering learning by EMET students; increase retention among EMET majors in the first two years; and provide upper division engineering majors the highest quality of education and academic experiences to foster the development of leadership and innovation skills necessary for future problem-solving. Program Goals and Objectives are summarized in Table 1 below.

Table 1. EDUCERE Goals and Objectives

Goals	Objectives
1. Improve Engineering Learning and Learning Environments: Improve the knowledge base for defining, identifying, and innovating effective undergraduate engineering education using evidence-based resources and pedagogies in undergraduate EMET education.	1) Perform a Matched Subjects Design study of Freshman engineering majors who enroll in ENGR 116 and students who do not, and compare levels of cognition in the sophomore level Engineering Physics I course. 2) Analyze the active/applied learning activities to determine if they correlate with increases in later success in Engineering Physics I. 3) Analyze the effectiveness of upper division research projects on preparedness for graduate school and workforce success. 4) Analyze the effectiveness of summer internships on graduate school preparedness and workforce success.
2. Broaden Participation for Engineering Learning: Increase the number of students recruited and retained in the EMET program.	1) Increase the number of declared EMET majors by 45%: from 22 students (current) to 32 students by 2019. 2) Increase retention rates of EMET majors by 27% from year one to two (55% current to 70%); and 79% from year one to three (28% current to 50%) by 2019.
3. Build the Professional Engineering Workforce for Tomorrow: Improve the preparation of undergraduates so they succeed as productive members of the future engineering workforce and be engaged in STEM-literate society.	1) Between 4 and 8 upper division students will engage in research activities during the academic year during years 2 and 3. 2) At least 4 upper division students will engage in research activities over the summer during years 2 and 3. At least 5 upper division students will participate in a local, regional or national meeting/conference in engineering over a 3-year period. 3) At least 6 upper division students will engage in a workforce summer internship or undergraduate research experience over a 3-year period.

Expected Significance: By meeting the stated objectives, the expected significance of this project will be: 1) increased student enrollment in the EMET program of highly underrepresented Hispanic, Native American and women populations; 2) increased first and second year retention among EMET majors, which will lead to increased graduation rates, as internal data indicate that if engineering students persist beyond the first year, they are 87% more likely to graduate; 3) increased degree completion among EMET majors, leading to increased URM in graduate programs and diversification of the engineering workforce; 4) greater motivation for additional curricular and course sequence changes in other STEM-H programs at Northern, which will lead to greater retention and higher numbers of URM students graduating with STEM-H degrees and entering the STEM-H workforce; 5) a broader knowledge base for understanding how Northern's unique, underrepresented and academically underprepared students best learn complex Physical Science concepts; and 6) better preparation of URM engineering graduates leading to greater diversification as well as innovation and problem-solving in the engineering workforce. The CET and its faculty are highly committed to graduate a greater diversity and percentage of URM students prepared to successfully enter graduate programs and/or careers in engineering. The short-term and long-term goals of the PI and Co-PI's of this project, as well as the Dean and other faculty in the CET, are to determine what elements are most conducive to creating a strong learning environment that supports a uniquely high-need student population to meet with academic success in STEM.

PRESENT STATE OF KNOWLEDGE IN THE FIELD

The ENGR 116 course is being modeled after the success experienced by Wright State University's Engineering Department in their development of an introductory project-based Math course with active learning activities designed for engineers, taught by engineering faculty, and specifically targeting Math-related attrition in their engineering programs. Klingbeil and Bourne (2012), using eight years of data, reported that the 'Wright State Model for Engineering Mathematics Education' program reduced impediments that Math under-preparedness historically posed for Freshman engineer majors; and more than doubled the graduation rate of enrolled students, with the greatest positive impact on URM. Given the low Math placement scores and high Math-related attrition experienced by Northern's engineering students, the CET developed a comparable Math course in 2009, *Basic Math for Engineering Applications* (ENGR 115), taught in the CET by engineering faculty, rather than in the Mathematics and Physical Sciences Department. This hands-on, applied learning Math course, initially created as a summer program with NSF-STEP funding and institutionalized in the CET in 2014, offers accelerated entry into calculus for engineer majors with great success. Students continue to show significant improvements in Math cognition and greater confidence in their overall Math skills, which continues to benefit them in their Math-intensive upper division engineering courses. Moreover, ENGR 115 has led to increases in first year retention from 50% to 76% between 2009 and 2014 among students taking the course (Lopez et al., 2013). The increased retention and graduation rates among engineering URM with active learning programs in Math, both at Wright State University and at Northern, provides a strong basis for the anticipated success expected with the early introduction of applied learning in Physics.

In addition, a substantial body of research has demonstrated improvements in student learning and positive impacts on lower-division student success and retention in STEM courses with the best-practice student support model, Peer-Led Team Learning (PLTL). This nationally recognized model of teaching and learning, developed originally for a Chemistry class at the City College of New York, has been adapted to many institutions nationwide across all STEM disciplines with noted success. In PLTL, upper division students who have done well in a course or subject serve as *peer-leaders* to lower division students taking the same course, and facilitate small-group learning. Peer-leaders will be integrated into the ENGR 116 course and will work with the small groups that form around the active learning activities and projects. They will serve as "teaching assistants" to the faculty, and will engage in problem solving and discussions regarding learning activity content with students, thereby supporting student learning in the immediacy of the activities and while active learning is taking place. Because these Peer Team Leaders have recently completed the coursework being taught, they can 'lead' the younger students through the learning process, as they are close to the material and to the student's point of view.

Finally, in support of maintaining a culture of innovation, creative ideas, and diverse approaches to problem solving, EMET faculty seek to foster the generation of analytical and problem solving abilities among its upper division engineering students. Northern's CET seeks to provide junior and senior-level students with undergraduate research and industry workforce experiences to better prepare them for graduate programs and a highly evolving and technologizing labor market. The literature has reported for more than three decades the substantial benefits for URM when engaging in undergraduate research opportunities, and myriad recent publications substantiate the importance. Foertsh, et al. reported on results from a 10-year longitudinal study (1986-1996) involving more than 5,400 minority undergraduate students who participated in research experiences in 15 Midwest R1 institutions. Of the 5,400 students who participated, 52% went on to graduate school, 35% completed their degrees and entered the workforce, and 23% attended professional schools. Students who participate in undergraduate research experiences derive a number of immediate and long-term benefits, including increased confidence in research and professional skills, enhanced preparation for graduate school, and greater clarity on future career pathways (Luchini-Colbry, et al., 2013). Undergraduate students who engage in research experiences also exhibit a greater interest in and commitment to pursuing graduate studies in STEM (Eagan et al., 2013), and will attend graduate programs in the sciences at far higher rates than the students who do not (Slovacek, et al., 2012). Several of Northern's doctorate-level STEM faculty are recipients of grants that support URE, including the NSF S-STEM engineering grant. Northern engineering faculty also collaborate on grant programs that support summer research experiences at large research institutions, and have strong partnerships with local industry, including the Los Alamos National Laboratory, to provide workforce development training for its students. Several of these research and industry collaborations are listed in the Facilities, Equipment and Other Resources document.

GENERAL PLAN OF WORK

What we want to do - Educere is Latin for *leading* or *drawing forth*, and this project proposes to lead EMET Freshman students with little or no science background through a modified course sequence for Physics that incorporates active learning exercises earlier in their program, *prior* to taking traditional Physics that utilizes more theoretical learning, in an effort to draw forth increases in cognition and confidence with difficult foundational concepts. Project-based learning is an active-learning pedagogy that has been used in STEM education to enhance cognition and retention, especially among URM. EMET faculty propose to design and create a new Freshman-level introductory Physics course, *Applied Sciences for Engineering Freshmen* (ENGR 116), that employs active learning projects specifically relating to engineering applications. This preparatory class will be the second in sequence and will follow the ENGR 115 introductory Math course students take in their first semester. All Freshman EMET engineering majors will be guided through academic advisement to enroll in both courses sequentially. Peer-led Team Leaders will work with faculty and students to support greater learning outcomes and depth of knowledge of Physics foundational principles.

In addition, EMET faculty will provide upper division EMET majors with faculty-mentored undergraduate research and workforce development training in a variety of industry-related internships. These activities have been shown to improve the quality of education, especially for URM. Studies also show that students who participate in URE derive increased confidence, enhanced preparation, greater clarity on future career pathways, and greater interest in and commitment to pursuing graduate studies and engineering careers.

Why we want to do it - The overwhelming majority of Freshman at Northern are academically underprepared and had little or no Math or Science in high school. Lack of college readiness is a major cause for low retention and degree attainment, as data show that the majority of students who begin in remedial courses never complete their college degrees (National Science Center for Public Policy and Higher Education, 2010). Furthermore, research on STEM undergraduate education shows that the critical point of departure for engineer and other STEM majors is between the first and second years of college, or even earlier (National Science Board, 2014). Northern's overall levels of attrition in the first (60%) and

second (50%) year are very high, as is the proportion of non-STEM degree choices made by students who have intrusive thoughts about their Math abilities. In an effort to decrease Freshman attrition levels related to the challenges they face with *basic* Math and Physics and foster greater URM success in engineering, the CET and its faculty aspire to broaden the knowledge base for understanding how Northern's unique and first generation population from lower socioeconomic backgrounds learn and gain problem-solving skills. Understanding these factors will better support their retention and persistence through degree completion in STEM programs, as well as mastering higher-order thinking skills that will lead to success in their upper division courses, in graduate school and/or in the professional engineering workforce.

Although more students in the US are pursuing graduate studies in STEM disciplines, Hispanic and Native American students continue to be considerably underrepresented. During the 2010-11 academic year, Native American, Black and Latino students represented only 0.4%, 3.8%, and 4.1% of all STEM graduate students, respectively. Moreover, URM women represented only 3.9% of Ph.D.'s in science and engineering, 5% of the workforce, and are twice as likely to be unemployed as their white female counterparts (National Science Foundation & National Center for Science and Engineering Statistics, 2013). Part of this underrepresentation can be attributed to URM attrition and lack of degree attainment, compared to their White and Asian counterparts (Hurtado et al., 2012). The fact that so few underrepresented racial minorities enroll in and complete graduate programs in STEM is compromising the country's ability to remain a leader in technology and innovation (President's Council of Advisors on Science and Technology, 2012). Because Hispanics are the fastest growing population in the US, they represent a significant potential pool for STEM workforce diversification. Despite considerable progress over the past two decades, the gap in educational attainment separating URM from Whites and Asians remains wide. With this project, the PI and Co-PI's seek to develop new evidence-generating approaches to improve retention and student success in STEM.

How we plan to do it - EMET and Social Science faculty will conduct rigorous research with well-established methodologies and frameworks to determine if the proposed incorporation of project-based active learning *earlier in the Physics sequence* and prior to the traditional theoretical learning approach to teaching Physics helps students with little or no science background to learn foundational concepts and succeed in the sophomore-level Engineering Physics I course, and beyond. Matched Subjects Design and a modified Solomon four-group design that mitigates threats to internal validity by reducing the influence of confounding variables, will be deployed to test the success of early active learning *prior* to theoretical learning on learning gains, cognition with foundational Physics concepts, and retention in the first two years. In addition, highly successful students who recently completed Engineering Physics I will be invited to serve as Peer Team Leaders and work with students in the newly introduced *Applied Sciences for Engineering Freshmen* course and in study groups to further increase learning outcomes and cognition. Learning assessments, based on Norman Webb's Depth of Knowledge Levels, which analyze the cognitive expectation demanded by the curricular activities (Webb, 1997), in combination with The Youth Program Quality Assessment instrument that will measure the quality of the course and its projects, will further ensure that ENGR 116 creates a rich environment where all students learn at a high level and gain the most from the active learning activities designed.

Additionally, two students per semester in years two and three of the project will be provided opportunities to engage in research internships during the academic year; five will attend regional engineering conferences; and ten will engage in summer research programs or industry-related summer internships. Upper division students will be offered a listing of potential research projects and workforce development opportunities and asked to apply for internships. Students will be selected based on their GPA, academic status, and commitment to engineering research and/or industry workforce development.

How we will know if we succeed - The data generated from the evidence-based social science research being implemented, which will measure the actual effect of early active learning methodology on cognition and future success in upper division, theory-based classes, is the key to determining the success of the project, and will broaden the CET's knowledge base for defining, identifying and innovating effective engineering education for its unique population. A series of learning assessments, described above and designed to measure the quality of the course and analyze the learning outcomes the curricular

activities are designed to foster, will provide formative information regarding changes in depth of knowledge, and offer valuable feedback for immediate interventions when assessments show that a particular lesson or project isn't working for students.

Finally, EMET faculty already have significant data (Lopez et al., 2013) showing that implementing an introductory Math course that incorporates project-based, engineering applied learning exercises increases student cognition and retention, as well as continued success in advanced engineering courses. Therefore, increases in student learning in the Engineering Physics I course among students who first enroll in ENGR 116, based on homework assignments, quizzes, exams and other student assessments, as well continued persistence and success in higher division courses, will suggest that the project-based Physics course earlier in the engineering sequence before being exposed to theory, was successful.

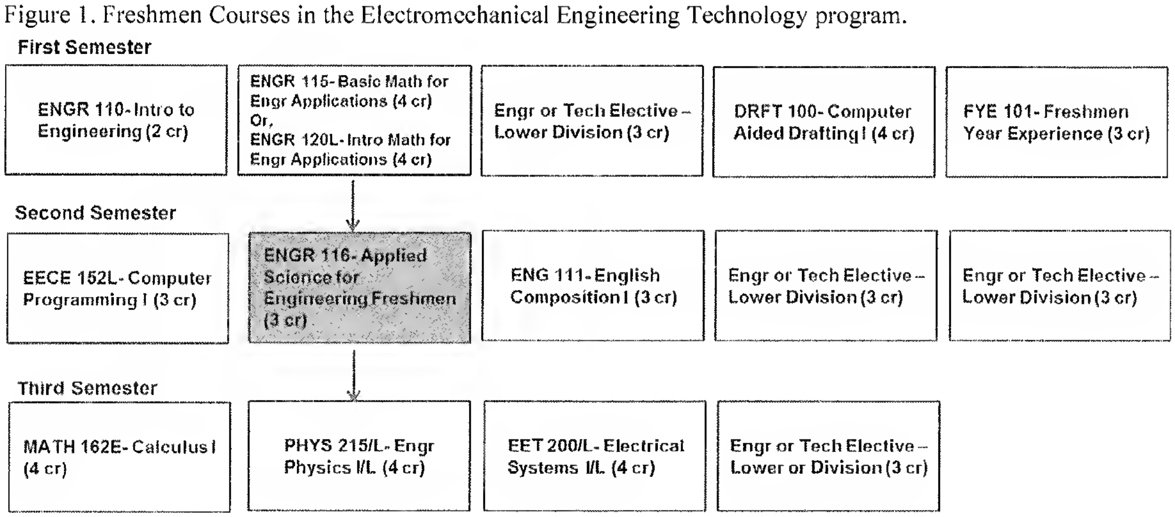
What benefits could accrue if the project is successful - The anticipated benefits for the EMET program include: a broader knowledge base for understanding how Northern's unique, underrepresented and academically underprepared students best learn complex Math and Physics concepts; increases in student comfort with and understanding of basic Physics and its engineering applications; greater success in Engineering Physics I and other advanced and interrelated courses in the EMET program; increases in first and second year retention and degree completion among more Hispanic, Native American and women students; and increased diversification of the engineering workforce. In addition to these immediate benefits for the EMET program and its students, evidence-based increases in cognition resulting from applied/active learning, project based pedagogies could impact other STEM-H programs and students at Northern, as well as other populations with similar demographics, if applied more broadly.

BROAD DESIGN OF ACTIVITIES

Applied Sciences for Engineering Freshmen Course

Proposed Curriculum for ENGR 116: ENGR 116 will focus on applied Math and Physical Science concepts necessary to develop a solid foundation for future engineering core courses. ENGR 116 will link with and reinforce the underlying Mathematics taught in ENGR 115 by exposing students to applied Physics concepts. This new course is envisioned as a three-credit course with 200 minutes of instructional time per week. Topics covered in this course are directly related to topics that will be covered in future courses in the EMET program sequence, as noted in Figure 1.

Figure 1. Freshmen Courses in the Electromechanical Engineering Technology program.



As a part of an overall initiative to reform engineering education at Northern, ENGR 116 will reinforce the understanding of working principles of many engineering applications in the first year. Students will be exposed to real-world and contemporary topics in the field, and will learn important engineering tools and software of practical industrial importance and relevance for 21st Century Learning.

This will help to prepare students for the workforce by keeping them up-to-date with contemporary industrial trends for career readiness. This also has the potential to increase interest in research and development, and in graduate studies in engineering and other STEM fields. An outline of the proposed Math, Science and Engineering competencies that will be introduced and/or reinforced through the active learning projects/experiments in the ENGR 116 course is provided in Table 2.

Table 2: Expected Competencies to be Reinforced in the ENGR 116 Course.

Math Concepts	• Algebra: Setting up and solving algebraic and quadratic equations, and exponents • Geometry: Straight lines, circles, triangles, rectangles and their properties, Pythagorean theorem • Trigonometry: Trigonometric functions and their use in Engineering • Derivatives: Understanding of derivatives as rate forms, application
Introduction to Science and Engineering Concepts	• Units and dimensions • Scalars and vectors • Force and their components, resultants • Friction • Motion analysis, displacement, velocity and acceleration • Basic understanding of Newton's laws, gravity • Pressure, temperature, volume and their dependence for gases (ideal gases) • Basic heat transfer mechanisms • Material properties and their quantification (stress-strain) • Internal forces on structural members (through load cell experiments) • Fundamentals of electricity: Ohm's law • Energy topics (renewable energy, electrical energy storage)
Programming and Software Skills	• Microsoft Office (Word, Excel, PowerPoint), Labview • Introduction to MATLAB • Informational literacy

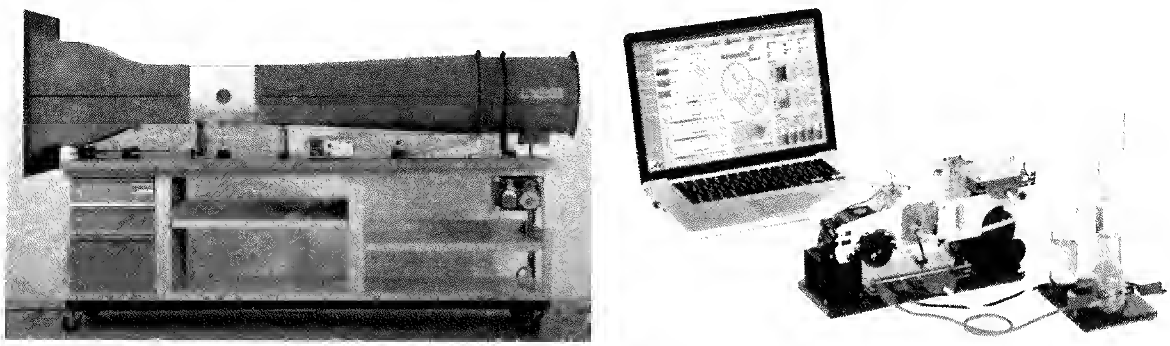
Hands-On Projects for ENGR 116: Hands-on, engineering contextualized projects will provide freshmen students in ENGR 116 with real-world industry applications and methodologies designed to enhance interest, increase cognition and critical thinking skills, and create a sense of *belonging* in the engineering field. Throughout this course students will be introduced to experimental techniques, data acquisition and analysis methodologies utilizing highly relevant engineering equipment. Two instruments which are necessary to teach many of these competencies include: 1) a subsonic wind tunnel; and 2) an electric vehicle trainer. The EMET program will purchase these two necessary pieces of equipment using grant funding, as detailed in the budget section. The EMET program is currently in possession of other useful equipment that will augment these two critical pieces of instrumentation, and together are sufficient to teach all of the basic concepts students must learn. Peer-led Team Leaders will support faculty and work closely with students in these lab settings to enhance cognition and learning outcomes.

Wind Tunnel - Through the use of classic aerodynamic experiments in the wind tunnel, Freshmen EMET students will be exposed to the process of scientific inquiry and will learn to employ specific methodology commonly utilized in the engineering field. Faculty and upper division students conducting research will guide these exercises for the Freshmen engineering students. The experiments and/or projects that the students will be exposed to are listed in Table 2. A picture of the wind tunnel with basic instrumentation is shown in Figure 2 (i).

Electric Vehicle Trainer - This instrument will be used for experiments involving renewable energy generation, storage and supply. The HyDrive® electric vehicle trainer allows students to examine the construction, functionality and benefits of hybrid electric vehicles (HEV); explore a multitude of theoretical and practical aspects of Fuel Cell Electric Vehicles (FCEV); and will prove instrumental in

teaching and conveying the scientific principles behind this technology. As such, it can be incorporated into general renewable energy-related courses. Hydrive includes sidecar chassis, mini-dyno/test bench controller, hydrogen generator/filling station, 5-cell fuel cell stack, super capacitor, on-board hydrogen gas storage tanks, control and data acquisition module, LabVIEW-based software and curriculum materials. A collection of electronic assignments, questions and measuring exercises for the fuel cell system on renewable energies will be given to students. A picture of the Fuel cell-Electric Vehicle Trainer is shown in Figure 2 (ii).

Figure 2. (i) Wind Tunnel with Basic Instrumentation. (ii) Hydrive®-Electric Vehicle Trainer (laptop not included).



(i) (ii)

Many interactive experiments/demonstrational sessions will be developed to enhance learning competencies and reinforce foundational concepts. Some of these are listed in Table 3.

Table 3. Experiments/Projects Utilizing New Equipment, and the Learning Competencies to be Learned/Reinforced.

Learning Competency	**Experiment/Project**
Force- drag and lift forces, displacement, angle	Experiments with drag bodies: airfoils, cylinder (drag and lift force variation with angle of attack)
Motion- displacement, velocity and acceleration and their relationships	Measurement of flow velocity by inclined tube manometer
Pressure and pressure measurement techniques, sensors	Experiments on pressure distribution on a cylinder and its relation to pressure drag force
Data acquisition and analysis	All experiments equipped with data acquisition and analysis software
Teamwork, hands-on, critical thinking	Simulating load profiles and evaluating drive cycles: city vs. highway; uphill vs. downhill, Economic analysis: comparing the cost of a battery powered EV to FCEV to vehicles with an internal combustion engine. Ideal FCEV configuration and maximum range: weight, rolling resistance and operating mode
Practical use of measuring instruments, data collection and analysis, technical writing and presentation	Use of didactic software for wireless Bluetooth system control, energy flow visualization, drive mode simulation, data analysis, lab reports
Introduction to materials science	Introduction to electric energy storage, Various types of Fuel cells, capacitors, learning fuel cell manufacturing process and system design

Upper Division Research Experiences and Professional Development

Engineering faculty will serve as Research Mentors to upper division students engaged in research experiences. These faculty-mentoring opportunities are intended to directly support students' professional development, problem-solving and analytical skills development and encourage their successful entrance into engineering graduate programs and professional careers. In year 2 and 3 of this project, two upper division EMET majors each semester will be selected on a merit-basis to participate in EDUCERE-sponsored, faculty-mentored, independent research projects using the subsonic wind tunnel or the electric vehicle trainer (see below). These students will be groomed to progress into graduate programs by being introduced to the process of scientific inquiry, experimental techniques, data acquisition and analysis methodologies. These upper division research students will also be provided with funding to travel to symposia, workshops or regional ASEE, TMS, IEEE or other relevant conferences where they will interact with other undergraduate researchers and professional scientists, and possibly present their research findings. Additionally, two upper division students will be provided with paid summer research and workforce development opportunities each summer for three years.

Wind Tunnel: To foster scientific inquiry and critical thinking skills, and to provide Northern's engineering upper division students with opportunities to gain experience with engineering equipment, this project proposes purchasing a subsonic open wind tunnel that offers an array of aerodynamic experiments/projects to explain and demonstrate many applied Physics and engineering concepts. The specific model HM 170 is an "Eiffel" type open wind tunnel and comes with various models and instrumentation. The flow in the measuring section is uniform with little to no turbulence. The lift and drag force can be measured for various models (circular cylinder, airfoil etc.), is detected and displayed digitally, and the corresponding air velocity is displayed on an inclined tube manometer.

Several interesting experiments and research projects can be conducted to measure pressure distribution (e.g., along the circumference of the cylinder) and to find drag and lift forces at varying Reynolds number of flow. Different drag bodies and airfoils will be used to determine aerodynamic properties (drag coefficient, lift coefficient, pressure coefficient, etc.) With guidance from faculty, upper division students will be conducting research-based projects using this wind tunnel and will be encouraged to present their work as posters in regional conferences.

Hydrive® Electric Vehicle Trainer: Hydrive is a hands-on trainer that allows students the opportunity to understand HEV and FCEV's. Students can explore a multitude of theoretical and practical aspects of FCEVs and experiment with construction, functionality and benefits of fuel cell HEVs. In particular, students can simulate and visualize various drive cycles, such as Inner City - Stop-and-Go, Highway, Uphill or Downhill, Supercapacitor Charge and Discharge and Regenerative Braking. The HyDrive allows hybrid electric vehicle topics to be taught, including: 1) Chemistry – Batteries, Supercapacitors, Hydrogen, Fuel Cell; 2) Mechanical – System Architecture, Thermal Management, Power Train, Regenerative Braking Electrical – Energy Conversion, Circuit Design; 3) Power – Power systems, Hybrid Design, Smart Grid; 4) Energy Management – Basic and Advanced System Configurations, Control of Energy Flow; 5) Software – Modeling, Simulation, Drive Mode Simulation, Varying Load Profiles.

Developing a STEM Literate Society

Northern New Mexico has a rich culture that over centuries has perfected organic small-scale agriculture and created a unique culinary style that has influenced an entire region. The Native and Hispanic people have also honed a musical and artistic creativity that draws people to the region from around the world. However, despite the development of the Los Alamos National Laboratory decades ago, the local people have remained rurally marginalized, undereducated, and have not benefitted or kept pace with the technological advances and scientific breakthroughs from which the rest of the country has prospered. In an effort to sow seeds that will contribute to a STEM-literate and college-going culture, bringing benefit to and improving the lives of individuals in the region, EDUCERE seeks to promote STEM literacy and the breaking down of barriers that have generated an unending cycle of poverty. Activities that promote STEM literacy for K-12 students and parents is the most critical, as the majority

of students at Northern are first generation and have little or no support or encouragement from their families once they get to college. Furthermore, when they arrive without any STEM background, the hurdles are significantly harder to overcome.

EDUCERE plans several activities to promote STEM literacy for the various communities and populations in the region, including organizing events such as *STEM Days@Northern* and *Engineering Days@Northern,* in which EMET students will showcase the wind tunnel and the Hydrive® electric vehicle trainer and demonstrate the concepts these instruments helped them to understand. In addition Northern has several STEM-specific programs and outreach activities for regional middle and high school students in which students both come to the Northern campus for interactive programs and in which teams of faculty and students travel to their school. In these events both CET faculty and upper division student researchers will present engineering projects and provide interactive, hands-on programs, as well as discuss workforce related facts and opportunities in engineering careers.

DESCRIPTION OF SOCIAL SCIENCE RESEARCH EXPERIMENTAL METHODS AND PROCEDURES

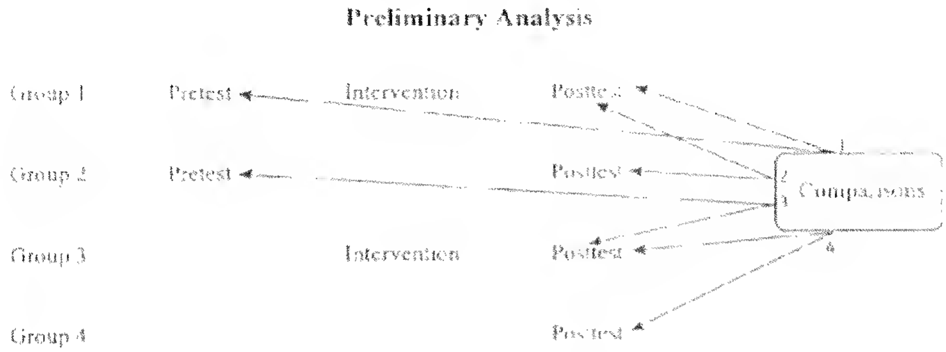
Many studies in social science that aim to estimate the effect of an intervention suffer from treatment selection bias. While groups are determined by random assignment to obtain approximately unbiased estimates of the effects of the intervention, random assignment is not possible in this case for practical reasons -- students have different majors and different course sequences, and there is a small sample size and few classes offered per term. To correct for this problem a matching samples procedure (Cook and Campbell, 1979) will compare pairs of the treatment group (students who take ENGR 116) and control group (students who do not take ENGR 116) for learning outcomes in the Engineering Physics I course to determine whether greater learning competency occurs when Physics is first introduced with active learning *prior* to theoretical learning. Pairs will be matched based on the following entering characteristics: basic math competency as based on Compass scores or their prior calculus class grade, gender, and ethnicity. A second analysis will look at whether Native American or rural Spanish students, both of whom come from highly integrative communities with high degrees of interdependent self-construal, learn Physics better as a result of being exposed to its application, as measured by interdependent versus independent self-construals.

Results for this study will be *ex post facto,* as the analyses of the outcome, i.e. estimating treatment effects through test scores and overall grades in the Engineering Physics I course, which both groups will take, can only take place after the propensity scores are obtained for both matched groups. There is a growing interest in using observational (or nonrandomized) studies to estimate the effects of treatments on outcomes. In observational studies, treatment selection is often influenced by subject characteristics. As a result, baseline characteristics of treated subjects often differ systematically from those of untreated subjects. Therefore, one must account for systematic differences in baseline characteristics between treated and untreated subjects when estimating the effect of treatment on outcomes. Historically, applied researchers have relied on the use of regression adjustment to account for differences in measured baseline characteristics between treated and untreated subjects. Recently, there has also been increasing interest in methods based on the propensity score to reduce or eliminate the effects of confounding when using observational data. A recent example where these methods were used is a Math study on the effects of small school size on Mathematics achievement (Wyse et al., 2008).

In addition, a modification of the Solomon four-group research design, presented in Figure 2, as outlined by Campbell and Stanley (1963), will be implemented due to the small sample size in the Engineering Physics I course. The modification is known as the Posttest-Only Control Group Design, which includes only Group 3 and Group 4. This design mitigates threats to internal validity. Applying the modified Solomon design may also lessen the Hawthorne effect, where participants are motivated to improve because they are aware that they are part of a study. The Posttest Only Control Group design will tease out which method of teaching leads to greater student achievement in Engineering Physics I: project-based active learning methods taught first, or the traditional path which first presents theoretical learning approaches. The analysis method generally used is a statistical test in which the posttest scores

(with matched pairs) are submitted to a 2x2 analysis of variance design. This analysis looks at the treatment effects, while controlling for outside variables.

Figure 3. Comparisons Using the Solomon Four-Group Design



Research Design and Questions to be Examined: Through an *ex post facto* quasi-experimental design with controls, the PI and Co-PI's will examine if and how the variation in presentation of Physical Science concepts (theoretical first or applied first) results in greater student academic achievement in the sophomore level Physics course. Table 4 summarizes the research design and questions to be examined.

Table 4. IUSE Social Science Research Design and Questions

Research Design	**Research Questions**
1) Create matched pairs to control for a small sample size and inability to randomly select. 2) Match on basic Math competency, as based on Compass scores, and matched by gender and ethnicity. Pairs will be examined for learning outcomes in the Engineering Physics I course. 3) Apply propensity scores to mimic randomization and control for entering differences in the treatment and controls. 4) Examine grades earned in Engineering Physics I course to determine which aspects of the treatment were effective, using a modified Solomon Four-Group design.	• Which method of presenting Physics concepts (theoretical first, or applied prior to theoretical) works best for student success in an advanced Physics course? • Do aspects of self-construal (independent/interdependent) unique to our local student population affect whether the applied approach first or the theoretical approach first is more effective in creating student mastery of Physics concepts?

Social Science Research and Assessments: The research will assess whether the changes in presentation of Physics foundational concepts support increased student success and achievement in the later, more complex, Engineering Physics I course. Analysis will utilize an *ex post facto*, matched pairs, modified Solomon Four-Group design. Table 5 outlines the goals and measures planned to implement this study of Northern's unique student population.

Table 5. Goals and Measures Planned

Project Goals	**Measures**
Define matched pairs of students enrolled in Engineering Physics I.	We will use the method of propensity scoring (Austin, 2011).

Project Goals	Measures
Measure independent and interdependent self-construal.	Independent and interdependent Self-Construal (Singelis, 1994).
Measure student achievement in Engineering Physics I.	Scores on content-based examinations.
Compare students who took ENGR 116 to students who did not.	Modified Solomon four-group. (Lavrakas, 2008).
Compare students who score high on interdependent to students who scored high on independent self-construal.	Modified Solomon four-group. (Lavrakas, 2008).
Assess treatment effects.	2x2 analysis of variance (Rosenthal and Rosnow, 2007).

BROADER IMPACTS OF THE PROPOSED WORK

The US maintains a technological edge through rigorous scientific research and technology development, and by maintaining a culture of innovation that generates diverse ideas and approaches to solving complex and multifaceted national and global problems. This project will recruit and train URM students to be highly skilled and well prepared to enter the STEM workforce through URE and workforce development training. By focusing on curricular and sequence modifications in the EMET program, more students will be retained and persist through degree completion, addressing the concern of low URM in engineering undergraduate and graduate programs and the STEM workforce. Finally, the people of this region possess widespread and generational creativity, as well as intellectual and cultural assets that will significantly contribute to the innovations and emerging breakthroughs in engineering. Positive results of introducing more Math- and Physics-deficient URM in their first year to real-life examples of engineering projects through active learning activities, and fostering greater achievement with foundational Physics concepts, will lead to more URM persisting in and graduating with engineering degrees, leading to more URM contributing to the diversity and ingenuity required to solve regional, national and global problems, and preserve the health and economic well-being of this and other nations.

Results from this experiment can also inform other similar unique cultural populations that can be defined as rural, underrepresented, not highly educated, interdependent, from similar socioeconomic backgrounds and emanating from families/communities in which the social fabric is strained, in terms of improving STEM retention, graduation rates, and innovation skills. Moreover, through the purchase of the wind tunnel and the Hydrive® electric vehicle trainer, the research and education infrastructure at Northern will be greatly enhanced for EMET students, as well as for middle and high school age children and their families, who will be introduced to Math and Physics using applied learning activities. These two critical pieces of equipment will therefore also support an increase in public scientific literacy in the region and help to promote a college-going culture. Finally, this project will continue to develop partnerships between large research institutions and industry in an effort to continue to improve the quality of STEM education for Northern's engineering students. The success of all of these activities combined will support greater well-being of the people of this region, and promote economic development and greater prosperity for the region.

OVERALL PROJECT EVALUATION

This project lends itself to a broad examination of the impact of: 1) early active learning experiences prior to theoretical learning in foundational courses such as Math and Physics; and 2) URE, faculty mentoring and professional development on URM motivation to attend graduate school. [redacted] will serve as the program evaluator and will work closely with faculty and mentors prior to,

during and after the project has commenced to ensure that maximum positive outcomes are attained. Using mixed-methods of analysis, the project evaluation will focus on two key facets.

The first is the impact of early active learning experiences prior to theoretical learning in Physics. The development of student leadership and problem-solving abilities will be the second focus of this project, including mentoring qualities that facilitate salient and positive future outcomes on engineering development and career clarity. This includes closely monitoring student's confidence levels and proficiency with research methodologies, and use of technology and communication/presentation skills.

The evaluation plan uses a mixed-methods approach to measure proximal outcomes and guide project leadership and faculty to make interim adjustments. In an effort to ensure that students progress satisfactorily, an outlined plan will be developed by faculty to complement the evaluation plan and most accurately measure quantitatively and qualitatively the success of each student in achieving the set learning- and skill-building goals. Assessments (formal and informal) will be administered to evaluate student's overall learning and enhanced understanding of Physics as a result of the new applied learning Physics course, and the research and mentoring experiences. Monthly formative evaluations throughout the project will ensure students' progress and that issues are worked through immediately. Summative analysis will provide results of what was most successful and will be the basis for future program development. Table 6 summarizes the evaluation questions, data sources and analysis methods.

Table 6. Evaluation Questions, Data Sources and Methods of Analysis.

Evaluation Questions	Sources of Data	Data collection timing/methods of analysis
Question 1: What evidence is there that a viable college course has been established and successfully integrated into the college program?		
1.1. What is the process of recruiting students and how successful is the process?	**1.1.** Interview project leadership, enrollment records	**1.1.** Years 1-3, 2x/yr., qualitative narrative analysis
1.2. Do professors and support staff perceive sufficient support to successfully teach the class?	**1.3.** Interview professors, support staff	**1.3.** Years 1-3, 2x/yr., qualitative narrative analysis.
1.3 How satisfied are students with the course content, active learning activities?	**1.3** Course evaluation form	**1.3** Years 1.3, 2x/yr., non-parametric techniques
Question 2: How effective is the program in meeting its yearly activities to conduct research related to student mastery of content, development of student non-cognitive traits (leadership, etc.), and college retention?		
2.1. Is the project on target regarding its research activities (administration of assessments, surveys, analysis, etc.)?	**2.1.** Interview project leadership, review of research	**2.1.** Years 1-3, 2x/yr. Qualitative narrative analysis
2.2. What challenges, if any, have been faced in implementing the research? What lessons have been learned?	**2.2.** Interview project leadership	**2.2.** Years 1-3, 2x/yr. Qualitative narrative analysis (QNA)
Question 3: How effectively is the new model of delivering Physics and STEM instruction establishing a learning trajectory for students and contributing to academic persistence?		
3.1. How do students' describe the integrated, activity based instruction compared to traditional instruction?	**3.1** Student survey, focus group with sample	**3.1.** Years 1-3, 2x/yr., non-parametric techniques, QNA
3.2 How do students' understanding related to Physics move from novice to expert?	**3.2** Student classroom assessments using Webb Depth of Knowledge (DOK) framework, concept maps	**3.2** Years 1-3, time series design (t1-t4) over course of each semester; analysis of change in DOK
3.3 How well do students demonstrate their ability to engage in activity based instruction to research Physics	**3.3** YPQA observation protocol (Engagement scales)	**3.3** Years 1-3; each activity by professor for formative assessment and feedback; each semester by

Evaluation Questions	Sources of Data	Data collection timing/methods of analysis
principles?		external evaluator
3.4 How is the faculty mentor program developing a community of learners that supports freshman in their first year?	**3.4** Student survey, faculty mentor interview/survey	**3.4** Years 1-3, 2x/yr; non-parametric techniques, QNA
3.5 What impacts are students reporting (depth of knowledge, problem solving, etc.) as a result of their participation in Peer Led Team Learning (PLTL)?	**3.5** Student survey and focus group	**3.5** Years 1-3, 2x/yr. non-parametric techniques, QNA
Question 4: What effect do the Upper division Research Experiences (URE) have on upper division students?		
4.1 What evidence is there that the UREs are improving students': a. Habits of Mind (preparation, persistence, resilience, etc.?) b. Interest in STEM-related careers? c. Commitment to pursuing graduate studies?	**4.1 a-c.** Student survey, focus group	**4.1 a-c.** Years 1-3, 2x/yr. non-parametric techniques, QNA

RESULTS FROM PRIOR NSF SUPPORT

<u>0757088 DUE STEP: STEM TALENT EXPANSION PROGRAM</u>: *Advancing STEM Performance, Innovation and Retention (ASPIRe)*; $499,065 total award; 06/15/2008 - 05/31/2013 (plus one-year no-cost extension); P.I. [redacted] more than 300 students participated in project activities; activities included Dual Credit with local high schools, a summer math enrichment program, an engineering First Year Experience course, tutoring in a variety of STEM fields, and STEM seminars with invited scholars; retention was originally 50% for first year students, and increased to 76% among STEP participants; 8% graduated with a degree in targeted STEM programs within five years. ***Project Outcomes***: The ASPIRe STEP grant focused on recruitment and retention. Services were provided to approx. 300 students (demographic distribution included 83% Hispanic, 5% Native American, 2% African American and 10% White, 46% female and 54% male). First Year Experience activities were very successful in exposing freshmen students to hands-on activities in the field. These activities are normally provided to juniors or seniors. In Fall 2013, the First Year Experience for engineering students showed a one-semester retention of 94% for participants. After tracking participating students for at least three semesters, the retention rate was 76%, compared to a 50% rate for first year students. Successful initiatives have been institutionalized, including Dual Credit with local high schools; and the "Math Accelerator Program," a math enrichment program taught in the College of Engineering, which is now the mandatory course, ENGR 115. Tutoring in a variety of STEM fields and STEM seminars with invited scholars also addressed many of the broader academic challenges that students face. ***Lessons Learned***: Results from this STEP program indicate that engineer majors who complete their first year are 87% more likely to graduate. Engaging students in research in their formative years, exposing them to faculty mentors, and providing professional seminars and cohort building activities enhances learning and retention.

<u>1259993 DUE S-STEM: SCHLR SCI TECH ENG & MATH, Engineering:</u> Pathways for Engineering: Access to Resources for Learning (PEARL); $621,708 total award; 08/01/2013 - 07/31/2018. P.I. [redacted] Co-PI [redacted], Co-PI [redacted]. $2,500 and $5,000 scholarships offered; 47 one-semester scholarships have been awarded over four semesters; three students have graduated in the 2-years of the award; 1 scholarship recipient has left the program to attend a larger institution. ***Project Outcomes***: Data for three semesters indicate that scholarships have helped the engineering programs with retention. Of the 22 recipients that received scholarships in the first three

semesters, only one student left the program. Three scholarship recipients have graduated and began working in their field before graduating. Also, students began taking an average of 1.5 credit hours more per semester after receiving scholarships; and 32% of scholarship recipients have engaged in research experiences and workforce related internships. ***Lessons Learned***: Community-building among faculty and students has been critical in the success of this Engineering S-STEM program. The gathering of students and faculty together for meetings, to engage in outreach activities, for seminars and other extracurricular activities has created a strong cohort and increased retention. In addition, providing first year students with hands-on approaches to learning, and offering tutoring services has positively impacted retention.

DISSEMINATION PLAN

EDUCERE will become a source of learned experiences for faculty, students and the regional and national community. It is very important to enable others to follow the best practices learned from this project. A multi-layered plan for dissemination includes:

- *Dissemination of research project results by students*: Students will have myriad opportunities to present their work at Northern's annual Science Symposium, at local and regional conferences, and at national meetings for those projects with strong and/or publishable results. Students can provide an oral seminar, a science poster or an abstract. In addition, students may have opportunities to publish their work in peer-reviewed journals and other non-peer-reviewed sources.
- *Dissemination of research project results by PI and Co-PI*: The social science research results and the active learning and changes in Physics course sequence that support student success will be presented at the American Sociological Association or the National Social Science Association Annual Meetings. Results will also be presented at local, regional and national meetings, including the Best Practices Conference of the Alliance for Hispanic Serving Institute Educators, the Society for Advancement of Chicano and Native American Students, and/or the Hispanic Association of Colleges and Universities. Positive results will be published in peer-reviewed and other non-peer-reviewed sources.
- *Dissemination on Northern's Website*: An EDUCERE program page on Northern's website will be developed to promote student interactions; post data and provide analyses; share success stories and published papers, articles, abstracts, posters and lessons learned.
- *Northern Foundation Dinner*: Student presentations will inform donors about program successes and research project results, which may inspire additional donations that support student scholarships.

INSTITUTIONALIZATION AND SUSTAINABILITY

This proposal is requesting seed money: to acquire necessary and critical lab equipment to offer students introductory applied/active learning and basic engineering research approaches; to pay for the development of course curriculum for ENGR 116; to pay upper division students to conduct research during the academic year, in the summer and to participate in workforce development experiences; to pay for PLTL peer mentors who will work with students in the ENGR 116 course and lead study groups during the semester; and to conduct research to determine if selected best practice interventions lead to greater cognition, retention and success in graduate programs and workforce careers.

Northern gives special consideration to those programs that have shown to improve cognition, retention and overall student success. In the case of the NSF-STEP grant, both the *First Year Experiences for Engineering* and the *Math Accelerator Program* initiatives were institutionalized once the grant expired. If the ENGR 116 course proves to be as effective as the ENGR 115 course, it will be institutionalized as part of the normal EMET program curriculum offered to students. With this project, the college will provide a meaningful first year experience for EMET majors with proven success to enhance students' academic skills, cognition and retention. Equipment will continue to be maintained through service contracts and utilized for many years by lower division and upper division students.

Finally, the CET's NSF-S-STEM grant provides scholarships and encourages students to engage in faculty-mentored research experiences. Given that this grant does not expire until 2018, funding can support additional EMET upper division student research experiences and professional development opportunities, thereby augmenting this grant's efforts.

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SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION	FOR NSF USE ONLY		
Northern New Mexico College	PROPOSAL NO.	DURATION (months)	
		Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR	AWARD NO.		
[redacted]			

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	1.65	[redacted]	
2. [redacted]	0.00	0.00	2.00	[redacted]	
3. [redacted]	0.00	0.00	2.00	[redacted]	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.65	35,532	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (10) UNDERGRADUATE STUDENTS				8,100	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				43,632	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				12,017	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				55,649	

D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)			
Electric Vehicle Trainer	$ 4,000		
Wind Tunnel	70,556		
TOTAL EQUIPMENT		74,556	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)		1,500	
2. INTERNATIONAL		0	
F. PARTICIPANT SUPPORT COSTS			
1. STIPENDS	$ 0		
2. TRAVEL	250		
3. SUBSISTENCE	0		
4. OTHER	0		
TOTAL NUMBER OF PARTICIPANTS (0)	TOTAL PARTICIPANT COSTS	250	
G. OTHER DIRECT COSTS			
1. MATERIALS AND SUPPLIES		1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION		0	
3. CONSULTANT SERVICES		5,000	
4. COMPUTER SERVICES		0	
5. SUBAWARDS		0	
6. OTHER		500	
TOTAL OTHER DIRECT COSTS		6,500	
H. TOTAL DIRECT COSTS (A THROUGH G)		138,455	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)			
TOTAL INDIRECT COSTS (F&A)		0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)		138,455	
K. SMALL BUSINESS FEE		0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)		138,455	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		

PI/PD NAME	FOR NSF USE ONLY		
[redacted]	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
[redacted]			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Northern New Mexico College**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR [redacted]				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. [redacted]	0.00	0.00	1.65	[redacted]		
2. [redacted]	0.00	0.00	2.00	[redacted]		
3. [redacted]	0.00	0.00	2.00	[redacted]		
4.						
5.						
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**		
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.65	**35,532**		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**		
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**		
3. (**0**) GRADUATE STUDENTS				**0**		
4. (**18**) UNDERGRADUATE STUDENTS				**20,100**		
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**		
6. (**0**) OTHER				**0**		
TOTAL SALARIES AND WAGES (A + B)				**55,632**		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**12,977**		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**68,609**		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				**0**		
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**3,000**		
2. INTERNATIONAL				**0**		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **500** 3. SUBSISTENCE **0** 4. OTHER **0**						
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**500**		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				**1,325**		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**		
3. CONSULTANT SERVICES				**5,000**		
4. COMPUTER SERVICES				**0**		
5. SUBAWARDS				**0**		
6. OTHER				**1,000**		
TOTAL OTHER DIRECT COSTS				**7,325**		
H. TOTAL DIRECT COSTS (A THROUGH G)				**79,434**		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**						
TOTAL INDIRECT COSTS (F&A)				**0**		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**79,434**		
K. SMALL BUSINESS FEE				**0**		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**79,434**		
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME [redacted]				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* [redacted]				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Northern New Mexico College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
[redacted]

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	1.65	[redacted]	
2. [redacted]	0.00	0.00	2.00	[redacted]	
3. [redacted]	0.00	0.00	2.00	[redacted]	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.65	**35,532**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**10**) UNDERGRADUATE STUDENTS				**20,100**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**55,632**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**12,977**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**68,609**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**4,500**	
2. INTERNATIONAL				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **500** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**500**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**1,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**500**	
3. CONSULTANT SERVICES				**5,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**1,500**	
TOTAL OTHER DIRECT COSTS				**8,500**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**82,109**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**82,109**	
K. SMALL BUSINESS FEE				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**82,109**	

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
[redacted]

ORG. REP. NAME*
[redacted]

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Northern New Mexico College

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
[redacted]

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	4.95	[redacted]	
2. [redacted]	0.00	0.00	6.00	[redacted]	
3. [redacted]	0.00	0.00	6.00	[redacted]	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	16.95	106,596	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (38) UNDERGRADUATE STUDENTS				48,300	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				154,896	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				37,971	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				192,867	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 74,556					
TOTAL EQUIPMENT				74,556	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				9,000	
2. INTERNATIONAL				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 1,250					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				1,250	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				3,825	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				500	
3. CONSULTANT SERVICES				15,000	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				3,000	
TOTAL OTHER DIRECT COSTS				22,325	
H. TOTAL DIRECT COSTS (A THROUGH G)				299,998	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				299,998	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				299,998	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME	FOR NSF USE ONLY		
[redacted]	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
[redacted]			

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

(A) Senior Personnel Costs

1) Compensation for the Principal Investigator: [redacted] is on a 9-month contract for $61,509 at Northern, and is committed to 0.35-Academic months of release time on an NSF-S-STEM grant. [redacted] is budgeted in this proposal for 1.65-Summer months salary of: $11,277 per year in Years 1-3. **Total Salary for 3-year program: $33,830.**

Over the course of this three-year project, [redacted] will serve: as the Principal Investigator and will assume responsibility for overall project management and annual grant reporting to NSF; in the co-development of course curricula and the co-teaching of the *Applied Sciences for Engineering Freshmen* (ENGR 116) course and its laboratory activities; in the preparing, administering and analyzing of learning assessments for technical content and learning outcomes for each of the laboratory exercises; in ordering, setting up and maintaining the wind tunnel instrumentation and necessary supplies; and in selecting, training and overseeing of Peer Mentors and their supportive activities. In addition, [redacted] will also work with and serve as a Research Mentor to one or two upper division students who will engage in undergraduate engineering research projects and the solving of advanced engineering problems with the wind tunnel during the academic year and during summer months; help student researchers to analyze, write up and present their results through posters or abstracts; and work towards building relationships with regional industries and colleges/universities who will be recruiting summer interns for workforce and academic research internships. Moreover, [redacted] will work closely with the social scientist Co-PI on data collection during the academic year and analysis over the summer; and will work closely with the overall project evaluator to assess the effectiveness of the course, its applied projects and learning assessments, as well the effectiveness of upper division research projects and summer internships in developing workforce development skills. This level of administrative, teaching and faculty-mentoring commitment requires 1.65-Summer months of compensation.

2) Compensation for Engineering Co-PI: [redacted] is on a 9-month contract for $60,546 at Northern. [redacted] is budgeted in this proposal for 2.0-Summer months salary of: $13,455 per year in Years 1-3. **Total Salary for 3-year program: $40,364.**

Over the course of this three-year project, [redacted] will serve: as Co-Principal Investigator and will support [redacted] in all aspects of the project, including: overall project management and annual grant reporting to NSF; in the co-development of course curricula and the co-teaching of the ENGR 116 course and its laboratory activities; in the preparing, administering and analyzing of learning assessments for technical content and learning outcomes for each of the laboratory exercises; in ordering, setting up and maintaining the Electric Vehicle Trainer instrumentation and necessary supplies; and in selecting, training and overseeing Peer Mentors and their mentoring activities. In addition, [redacted] will also work with and serve as a Research Mentor to one or two upper division students who will engage in undergraduate engineering research projects and the solving of advanced engineering problems with the Electric Vehicle Trainer during the academic year and during summer months; help his student researchers to analyze, write up and present their results through posters or abstracts; and work towards

building relationships with regional solar industries and colleges/universities who will be recruiting summer interns for workforce and academic research internships. Moreover, [redacted] will work closely with the PI and the social scientist Co-PI on data collection during the academic year and analysis over the summer; and will work closely with the overall project evaluator to assess the effectiveness of the course, its applied projects and learning assessments, as well the effectiveness of upper division research projects and summer internships in developing workforce development skills. This level of administrative, teaching and faculty-mentoring commitment requires 2.0-Summer months of compensation.

<u>3) Compensation for Social Scientist Co-PI</u>: [redacted] is on a 10-month contract for $54,000 at Northern. [redacted] is budgeted in this proposal for 2.0 Summer-months salary of: <u>$10,800 per year in Years 1-3</u>. **<u>Total Salary for 3 years: $32,400.</u>**

[redacted] will be conducting and overseeing the social science research, data collection and data analysis. [redacted] will work closely with the two Engineering Co-PI's and two undergraduate psychology/social science undergraduate students on the specific data to be collected each semester and will spend the summer undergoing data analysis. The scientific design and methodology are detailed in the project narrative. [redacted] will also work with the external evaluator over the summer where evaluation and assessment overlap. This level of research commitment requires 2.0-Summer months of compensation.

<u>Total Salary Compensation for PI and Co-PI's for the 3 Year Project Period: $106,594</u>

(B) Other Personnel Costs: Undergraduate Students

<u>1) Academic Year Research Stipends</u> – Two upper division students per semester in Year 2 and 3 will be provided with a $1,750 stipend each ($12.50/hr x 10 hr/wk x 14 wks/semester) to engage in faculty-mentored, independent research using the Open Wind Tunnel or Electric Vehicle Trainer. Total Stipends in <u>Year 2 = $7,000</u> for four students. Total stipends in <u>Year 3 = $7,000</u> for four students.

Total Academic Year Research Stipends for 2 Years = $14,000.

<u>2) Summer Research Experience Stipends</u> – Two upper division students each summer in Year 2 and 3 will be provided with a $2,500 stipend each ($12.50/hr x 20 hr/wk x 10 wks) to engage in faculty-mentored, independent research using the Open Wind Tunnel or Electric Vehicle Trainer. Total Stipends in <u>Year 2 = $5,000</u> for two students. Total stipends in <u>Year 3 = $5,000</u> for two students.

Total Summer Research Stipends for 2 Years = $10,000.

<u>3) Summer Workforce Internship Stipends</u> – Two students per summer in Years 1 - 3 will be provided with a $1,250 stipend each ($12.50/hr x 100 hrs) for summer workforce training in one of several regional facilities, including Los Alamos National Laboratory; Biohabitats - Southwest Basin and Range; and National Renewable Energy Laboratory. <u>Total Stipends in Year 1 =</u>

$2,500 for two students. Total Stipends in Year 2 = $2,500 for two students. Total Stipends in Year 3 = $2,500 for two students.

Total Summer Workforce Internship Stipends for 3 Years = $7,500.

4) Peer-led Team Learning Mentors Stipends – Two students per semester in Year 1 – 3 will be provided with $700 stipends each ($10/hr x 5 hr/wk x 14 wks) to work support faculty and students in the ENGR 116 course, as described in the Project Description. Total Stipends in Year 1 = $2,800 for four students. Total Stipends in Year 2 = $2,800 for four students. Total Stipends in Year 3 = $2,800 for four students.

Total Peer-led Team Learning Stipends for 3 Years = $8,400.

5) Social Science Student Data Research Assistant Stipends – Two students per semester in Years 1 – 3 will be provided with $700 stipends each ($10/hr x 5 hr/wk x 14 wks/) to work with the Social Science Co-PI faculty on data collection, analysis and input. Total Stipends in Year 1 = $2,800 for four students. Total Stipends in Year 2 = $2,800 for four students. Total Stipends in Year 3 = $2,800 for four students.

Total Social Science Student Data Research Assistants Stipends for 3 Years = $8,400.

Total Other Personnel Student Stipends for 3 Year Project Period = $48,300.

(C) Fringe Benefits

A 32% fringe benefit rate is included for the PI and two Co-PI's; and an 8% fringe benefit rate is included for all undergraduate students. The total benefits combined for both groups per year are: Year 1: $12,017; Year 2: $12,977; and Year 3: $12,977.

Total Fringe Benefits for 3 Year Project Period: $37,973.

(D) Equipment

Equipment will be purchased in the summer of Year 1 in order to have two new laboratories up and running by the Fall Semester. Both pieces of equipment are vital to the academic and professional development of both Freshmen and Upper Division students. The two pieces of equipment to be purchased are:

1) Model HM 170 "Eiffel" type open wind tunnel: This piece of equipment will be used to create an aerodynamics lab necessary to teach Applied Physics to Freshmen students using engineering applications; and for faculty-mentored independent research for upper division students being groomed for graduate research programs and university teaching. This subsonic open wind tunnel offers a wide array of aerodynamic experiments/projects to explain and demonstrate many applied physics and engineering concepts (as described in the Project Description). The wind tunnel comes with various models and instrumentations. The flow in the measuring section is uniform and with almost no turbulence. The lift and drag force could be measured for various

models (circular cylinder, airfoil etc.), are detected and displayed digitally, and the corresponding air velocity is displayed on an inclined tube manometer. Myriad interesting and math/physics reinforcing experiments/projects can be conducted for many levels of capability. The cost of the multipurpose wind tunnel and all necessary attachments is $70,556.

2) HyDrive® Electric Vehicle Trainer: This piece of equipment is necessary to teach students engineering applications involving renewable energy generation, storage and supply in the ENGR 116 course; and for faculty-mentored independent research for upper division students. This instrument allows students to examine the construction, functionality and benefits of hybrid electric vehicles; explore a multitude of theoretical and practical aspects of Fuel Cell Electric Vehicles; and will assist faculty in conveying the scientific principles behind this technology. The total cost is $4,000.

Total Cost of Equipment for Project: $74,556.

(E) Travel

The PI and Co-PI's will travel to engineering, social science and education conferences annually in the first two years, and for dissemination purposes in the final project year. Both in- and out-of-state travel for professional development/dissemination is budgeted. In Year 1, only one the PI will travel. In Year 2, the PI and the Social Science Co-PI will travel. In Year 3, the PI and both Co-PI's will travel for dissemination. Year 1 total travel cost = $1,500; Year 2 total travel cost = $3,000; Year 3 total travel cost = $4,500.

Total PI/Co-PI Travel for 3 Year Project Period = $9,000.

(F) Participant Support

Five **Travel Stipends** of $250 each will be offered to upper division students to travel for professional development to local and regional conferences, symposia and workshops. In Year 1 only 1 student will travel. In Years 2 and 3, two students will travel.

Total Student Travel for 3 Year Project Period = $1,250.

(G) Other Direct Costs

Materials: Basic supplies, including poster materials, copies, paper, printer cartridges, etc., at $1,000 Year 1; $1,325 in Year 2; and $1,500 in Year 3.

Total Supplies for 3 Year Project Period = $3,825.

Consultant: External Evaluator – [redacted] will provide overall project evaluation for the 3 Year project period. For services, she will receive $5,000 per year for 3 years.

Total External Evaluator for 3 Year Project Period = $15,000.

Publication/Dissemination: $500 for Year 3 for publication costs.

Total Publication/Dissemination for 3 Year Project Period = $500.

Other: Conference Registration fees for faculty to attend conferences at $500 for Year 1; $1,000 in Year 2; and $1,500 in Year 3.

Total Conference Registration Fees for 3 Year Project Period = $3,000.

Total Other Direct Costs for 3 Year Project Period = $22,325.

TOTAL DIRECT COSTS FOR 3 YEAR PROJECT PERIOD = $299,998.